2.4 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

2.4.1 Sacramento River Winter-run Chinook Salmon

2.4.1.1 Status of Sacramento River Winter-Run Chinook in the Action Area

The action area encompasses the entire critical habitat designation for winter-run Chinook salmon and includes almost all habitats utilized throughout the lifecycle of this species. Assessing the temporal occurrence of each life stage of winter-run Chinook in the action area is done through monitoring data in the Sacramento River and Delta as well as salvage data from the Tracey and Skinner fish collection facilities in the south Delta (CVP and SWP) (Table 1-1).

Table 3-1 shows the temporal occurrence of adult (a) and juvenile (b) winter-run in the Sacramento River. Darker shades indicate months of greatest relative abundance.

Table 3-1. The Temporal Occurrence of Adult (a) and Juvenile (b) Winter-run in the Sacramento River.

Winter run relative abundance	High				Medium				Low			
a) Adults freshwater												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River basin[a,b]												
Upper Sacramento River spawning[c]												
b) Juvenile emigration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River at Red Bluff [d]												
Sacramento River at Knights Landing[e]												
Sacramento trawl at Sherwood Harbor[f]												
Midwater trawl at Chipps Island[g]												

Sources: [a] (Yoshiyama *et al.* 1998); (Moyle 2002); [b](Myers *et al.* 1998) ; [c] (Williams 2006) ; [d] (Martin *et al.* 2001); [e] Knights Landing Rotary Screw Trap Data, CDFW (1999-2011); [f,g] Delta Juvenile Fish Monitoring Program, USFWS (1995-2012)

Spawning adult winter-run Chinook salmon begin their upstream migration through the Sacramento/San Joaquin Delta in December and continuing through July with a peak occurring between the months of December and April (U.S. Fish and Wildlife Service 1995, National Marine Fisheries Service 2014c). Adult winter-run Chinook salmon return from the ocean prior to reaching full sexual maturity and hold in the Sacramento River for several months before spawning while they mature. Currently, the spawning range of winter-run Chinook salmon is confined to the Sacramento River between Red Bluff Diversion Dam (RBDD) (RM 243) and Keswick Dam (RM 302) (Vogel and Marine 1991, National Marine Fisheries Service 2014c). Historically, spawning likely occurred upstream of Shasta Dam in spawning reaches which are no longer accessible to anadromous fish (Yoshiyama *et al.* 1998).

The upper Sacramento River below Keswick Dam portion of the action area is critically important for the survival and recovery of this species as it contains the only known remaining spawning grounds. As winter-run spawning occurs in the summer months, naturally occurring summer flows in river reaches below Keswick Dam, where this species currently spawns, would have precluded spawning historically. This suggests that the area below Shasta and Keswick Dams was likely utilized for winter-run juvenile rearing and migration. Currently, flows in the Sacramento River are artificially managed at both Keswick and Shasta Dams in order to provide appropriate spawning and egg incubation temperatures and flows through winter-run spawning grounds (Boles 1988, Yates *et al.* 2008, National Marine Fisheries Service 2014d). There is an ongoing effort to restore 42 miles of salmon habitat on Battle Creek as a result of Pacific Gas and Electricity's application to the Federal Energy Regulatory Commission to modify operations of hydropower projects on the North and South Forks of Battle Creek (National Marine Fisheries Service 2009e). This additional spawning and rearing habitat is expected to be utilized by winter-run Chinook salmon and to aid in the recovery of this species.

There are uncertainties about Reclamation's ability to maintain an adequate cold water pool in order to maintain suitable temperatures for winter-run Chinook salmon egg incubation, fry emergence, and juvenile rearing in the Sacramento River in critically dry years and extended drought periods. Through the 2009 CVP/SWP long-term water operations biological opinion, Reclamation has created and implemented improved Shasta Reservoir storage plans and year-round Keswick Dam release schedules and procedures to provide cold water for spawning and rearing (National Marine Fisheries Service 2016e).

However, warm water releases from Shasta Dam have been a significant stressor to winter-run Chinook salmon, especially given the recent extended drought in California from 2012 through 2015 (National Marine Fisheries Service 2016c). Warm water releases from Shasta Reservoir in 2014 and 2015 contributed to 5.9% and 4.2% egg-to-fry survival rates to RBDD in 2014 and 2015, respectively. Under varying hydrologic conditions from 2002 to 2013, winter-run Chinook salmon egg-to-fry survival ranged from three to nearly 10 times higher than in 2014 and 2015. Measures taken to reduce this threat and improve Shasta Reservoir cold water pool management have been to: (1) relax Wilkins Slough navigational flow requirements; (2) relax D-1641 Delta water quality requirements; (3) delay Sacramento River Settlement Contractor depletions, and transfer a volume of their water in the fall rather than increase depletions throughout the summer; (4) target slightly warmer temperatures during the SR winter-run Chinook salmon holding period (before spawning occurs); (5) replace the Spring Creek and Oak Bottom temperature control curtains in Whiskeytown Reservoir; and (6) install the Shasta Dam temperature control device curtain in 2015 (National Marine Fisheries Service 2016e). Other efforts to reduce the threat of warm water releases from Shasta Dam include improving reservoir, meteorologic, and hydrologic modeling and monitoring in order to most efficiently manage the reservoir's limited amount of cold water, installation of additional temperature monitoring stations in the upper Sacramento River to better monitor real-time water temperatures, and enhanced redd, egg, and juvenile SR winter-run Chinook salmon monitoring (National Marine Fisheries Service 2016e).

Regardless of current operational conditions in the action area, water temperatures are expected to increase in the Central Valley of California due to air temperature warming (Lindley 2008, Beechie *et al*. 2012, Dimacali 2013) and reduced precipitation (i.e., more frequent drought conditions; Yates et al. 2008) from climate change. These factors will compromise the quantity and/or quality of winter-run Chinook salmon habitat available downstream of Keswick Dam into the future.

The Livingston Stone National Fish Hatchery (LSNFH) began operation in 1997 and functions to supplement the naturally occurring population of Sacramento River winter-run Chinook salmon in order to aid in its survival and recovery (California Hatchery Scientific Review Group (California HSRG) 2012). The facility is intended to be a temporary conservation measure and will cease operations once the population of winter-run is considered to be viable and fully recovered. Winter-run that are produced at LSNFH are intended to return to the upper Sacramento River as adults and become reproductively and genetically assimilated into the natural population (California Hatchery Scientific Review Group (California HSRG) 2012).

Juvenile winter-run Chinook salmon use the Sacramento River for rearing and migration and small numbers have also been shown to utilize the Lower American River for rearing (Reclamation 2015). Juveniles migrate downstream through the Sacramento River in late fall/early winter. Until 1978 when the State Water Resources Control Board instituted closures of the Delta Cross Channel (DCC) to protect migratory fish, the DCC posed a threat of entrainment into the interior Delta for outmigrating juvenile winter-run. Following the institution of additional operational criteria for the DCC, it now remains closed from February 1st through May 20th, protecting outmigrating juvenile winter-run and preventing entrainment (National Marine Fisheries Service 2009a).

Juvenile winter-run Chinook salmon begin to enter the Delta in October and outmigration continues until April. Juvenile outmigration timing is thought to be strongly correlated with winter rain events that result in higher flows in the Sacramento River (del Rosario *et al.* 2013). Winter-run use the Delta primarily as a migration corridor as they make their way to Suisun and San Pablo Bays and eventually the Pacific Ocean. Relative abundance in the Delta is inferred through salvage monitoring data, CDFW rotary screw trap sampling, and U.S. Fish and Wildlife Service (USFWS) Delta Juvenile Fish Monitoring Program (DJFMP) data (see Appendix XX for more information). Juvenile mortality in the Delta and San Francisco estuary continues to be investigated. A conclusive primary source has yet to be identified, though Delta outflow seems to play an important role (Baker and Morhardt 2001). Predation by piscivorous fish has been at the forefront of this debate and multiple studies have attempted to address the scale at which this source of mortality is affecting the population as a whole (Lindley and Mohr 2003, Demetras *et al.* 2016).

For winter-run Chinook salmon, the embryonic and larval life stages that are most vulnerable to warmer water temperatures occur during the summer (Boles 1988), so this run is particularly at risk from climate warming. The only remaining population of winter-run Chinook salmon relies on the cold water pool in Shasta Reservoir, which buffers the effects of warm temperatures in most years. The exception occurs during drought years, which are predicted to occur more often with climate change (Yates et al. 2008). The long-term projection of operations of the CVP/SWP expects to include the effects of climate change in one of three possible forms: less total precipitation; a shift to more precipitation in the form of rain rather than snow; or, earlier spring snow melt (Reclamation 2008). Additionally, air temperature appears to be increasing at a greater rate than what was previously analyzed (Lindley 2008; Beechie et al. 2012; Dimacali 2013). These factors will compromise the quantity and/or quality of winter-run Chinook salmon habitat available downstream of Keswick Dam into the future. For this reason, it is imperative for additional populations of winter-run Chinook salmon to be re-established into historical habitat in Battle Creek and above Shasta Dam for long-term viability of the ESU (NMFS 2014a).

2.4.1.2 Status of Sacramento River Winter-run Chinook Critical Habitat in the Action Area

The proposed action area encompasses the majority of the range-wide riverine and estuarine critical habitat PBFs for winter-run. Wide-spread degradation to these PBFs has had a major contribution to the status of the winter-run ESU. PBFs (as discussed in the range wide status of the species section [Section 2.2]) include: (1) access from the Pacific Ocean to appropriate spawning areas in the Upper Sacramento River, (2) the availability of clean gravel for spawning substrate (3) adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, (4) water temperatures between 42.5 and 57.5°F (5.8 and 14.1°C) for successful spawning, egg incubation, and fry development, (5) habitat and adequate prey that are not contaminated, (6) riparian habitat that provides for successful juvenile development and survival, and (7) access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean.

Passage impediments in the northern region of the Central Valley are largely responsible for isolating the existing population from historical spawning reaches. These reaches occurred upstream of Keswick and Shasta dams and included the upper Sacramento River, McCloud River, Pit River, Fall River and Hat Creek (Yoshiyama *et al.* 1996, Lindley *et al.* 2004, National Marine Fisheries Service 2014d). Due to the installation of Keswick and Shasta Dams, the winter-run ESU is now relegated to spawning in the Sacramento River. The majority of spawning occurs between Red Bluff (Red Bluff Diversion Dam) and Redding (below Keswick Dam) (Vogel and Marine 1991, National Marine Fisheries Service 2014c). PBFs #2-4 for this ESU have been degraded in a number of ways. Spatially, the total area of viable spawning habitat has been significantly diminished. Physical features that are essential to the functionality of existing spawning habitat have also been degraded such as: loss of spawning gravel, and elevated water temperatures during summer months when spawning events occur (National Marine Fisheries Service 2014c). Degradation of these features is actively mitigated through real-time temperature and flow management at Shasta and Keswick dams (National Marine Fisheries Service 2009d) as well as gravel augmentation projects in the affected area; set to occur under a multi-year programmatic authority (National Marine Fisheries Service 2016b).

PBFs related to the rearing and migration of juveniles and adults have been degraded from their historical condition within the action area as well. Adult passage impediments on the Sacramento River existed for many years at the Red Bluff Diversion Dam (RBDD) and Anderson-Cottonwood Irrigation District's (ACID) diversion dam (National Marine Fisheries Service 2014c), however, the RBDD was decommissioned in 2013 providing unimpaired juvenile and adult fish passage and a fish passage improvement project at the ACID was completed in 2015, so that adult winter-run Chinook salmon could migrate through the structure at a broader range of flows reaching spawning habitat upstream of that structure.

Juvenile migration corridors are impacted by reverse flows in the Delta that become exacerbated by water export operations at the CVP/SWP pumping plants. This is thought to result in impaired routing and timing for outmigrating juveniles and is evidenced by the presence of juvenile winter-run at the state and federal fish salvage facilities. This impact is discussed in greater detail in Section 1.1.1.1.12 *Hydrodynamics in the Delta*. Shoreline armoring and development has reduced the quality and quantity of floodplain habitat for rearing juveniles in the Delta and Sacramento River (Williams *et al.* 2009, Boughton and Pike 2013). Juveniles have access to floodplain habitat in the Yolo Bypass only during mid to high water years, and the quantity of floodplain available for rearing during drought years is currently limited. The Yolo Bypass Restoration Plan includes notching the Fremont Weir which will provide access to floodplain habitat for juvenile salmon over a longer period (Department of Water and Resources and Bureau of Reclamation 2016).

2.4.2 Central Valley Spring-run Chinook Salmon and California Central Valley Steelhead

2.4.2.1 Status of Central Valley Spring-run Chinook in the Action Area

The Sacramento River, American River and Sacramento/San Joaquin Delta are included in the action area and are extensively utilized by various life stages of the Central Valley spring-run Chinook salmon ESU. Assessing the temporal occurrence of each life stage of spring-run Chinook salmon in the action area is done through analysis of monitoring data in the Sacramento River and select tributaries; monitoring in the Delta; and salvage data from the Tracey and Skinner fish collection facilities in the south Delta (CVP and SWP) (Table 2-2).

Table 2-2. The temporal occurrence of adult (a) and juvenile (b) Central Valley spring-run Chinook salmon in the mainstem Sacramento River

(a) Adult migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River basin[a,b]												
Sac. River Mainstem[b,c]												
(b) Adult Holding[a,b]												
(c) Adult Spawning[a,b,c]												
(d) Juvenile migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River Tribs[d]												
Sac. River at RBDD[c]												
Sac. River at KL[e]												

Relative Abundance: = High = Medium = Low

Sources: [a]Yoshiyama et al. (1998); [b]Moyle (2002); [c]Myers *et al.* (1998); [d]CDFG (1998); [e]Snider and Titus (2000)

Adult spring-run Chinook salmon enter the San Francisco estuary to begin their upstream spawning migration in late January and early February (California Department of Fish and Game 1998b). They enter the Sacramento River between March and September, primarily in May and June (Yoshiyama *et al.* 1998, Moyle 2002). Generally, adult spring-run Chinook salmon are sexually immature when they enter freshwater habitat and must hold in deep pools for up to several months in preparation for spawning (Moyle 2002). The spawning range of CV spring-run Chinook is outside of the action area, located in several tributaries to the Sacramento River (National Marine Fisheries Service 2014b). The Delta and Sacramento River, however, provide a critical migration corridor for spawning adults, allowing them access to spawning grounds upstream.

Monitoring of the Sacramento River mainstem during spring-run Chinook salmon spawning timing indicates that some spawning occurs in the river. Significant hybridization with fall-run Chinook salmon makes identification of spring-run Chinook salmon in the mainstem very difficult, but counts of Chinook salmon redds in September are typically used as an indicator of spring-run Chinook salmon abundance. Less than fifteen Chinook salmon redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts (U.S. Fish and Wildlife Service 2003). Redd surveys conducted in September between 2001 and 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the RBDD, ranging from 3 to 105 redds; in 2012, zero redds were observed, and in 2013, 57 redds were observed in September (California Department Fish and Wildlife, unpublished data, 2014).

Therefore, even though physical habitat conditions in the upper Sacramento River can support spawning and incubation, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With the onset of fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning, it is likely that extensive introgression between the populations has occurred (California Department of Fish and Game 1998a).

Currently, the only known streams that support self-sustaining, non-hybridized populations are Mill, Deer and Butte creeks, located east of the mainstem Sacramento River with headwaters sourced in the Sierra Nevada foothills (National Marine Fisheries Service 2014c), which is not within the action area of this proposed action.

The Sacramento River functions as both rearing habitat for juveniles and the primary migratory corridor for outmigrating juveniles and spawning adults. The juvenile life stage of CV spring-run Chinook salmon exhibits varied rearing behavior and outmigration timing. Juveniles may reside in the action area for 12-16 months (these individuals are characterized as “yearlings”), while some may migrate to the ocean as young-of-the-year (National Marine Fisheries Service 2014c).

The Delta is utilized by juveniles prior to entering the ocean. Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Juvenile spring-run Chinook salmon use Suisun Marsh extensively as a migratory pathway, though they likely move through quickly based on their size upon entering the bay (as compared to fall-run which enter this area at a smaller size and likely exhibit rearing behavior prior to continuing their outward migration) (Brandes and McLain 2001, Williams 2012).

Some non-natal juvenile rearing has been observed in the Lower American River; however, there is no longer a viable population of CV spring-run Chinook associated with that system (Reclamation 2015).

An experimental population of spring-run Chinook salmon has been designated under section 10(j) of the ESA in the San Joaquin River from Friant Dam downstream to its confluence with the Merced River (78 FR 79622, December 31, 2013), and spring-run Chinook salmon are currently being reintroduced to the San Joaquin River . The experimental population area in the San Joaquin River is outside the action area. However, when these fish migrate to and from the ocean, they will pass through the action area, where they are considered part of the non-experimental Central Valley spring-run Chinook salmon ESU. A conservation stock of spring-run Chinook is being developed at the San Joaquin River Conservation and Research Facility at Friant Dam and individuals have been released annually since 2014 to the lower San Joaquin River. In 2016, the San Joaquin River Restoration Program released 57,320 Feather River Hatchery and 47,560 San Joaquin River Conservation and Research Facility spring-run Chinook salmon juveniles to the San Joaquin River just upstream of the confluence with the Merced River. 2016 was the first year in which the fish released in 2014 may have returned. No fish have been detected returning to the San Joaquin River to spawn from the initial 2014 release.

In addition, observations in the last decade suggest that spring-running populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2014). Although the exact number of spring-running Chinook salmon in the San Joaquin basin is unknown, juvenile and adult spring-run use the portion of the lower San Joaquin River within the Delta as a migratory pathway.

Spring-run Chinook salmon adults are vulnerable to climate change because they over-summer in freshwater streams before spawning in autumn (Thompson et al. 2011). Spring-run Chinook salmon spawn primarily in the tributaries to the Sacramento River, and without cold water refugia (usually input from springs), those tributaries will be more susceptible to impacts of climate change. Even in tributaries with cool water springs, in years of extended drought and warming water temperatures, unsuitable conditions may occur. Additionally, juveniles often rear in their natal stream over the summer prior to emigrating (McReynolds *et al.* 2007), and would be susceptible to warming water temperatures.

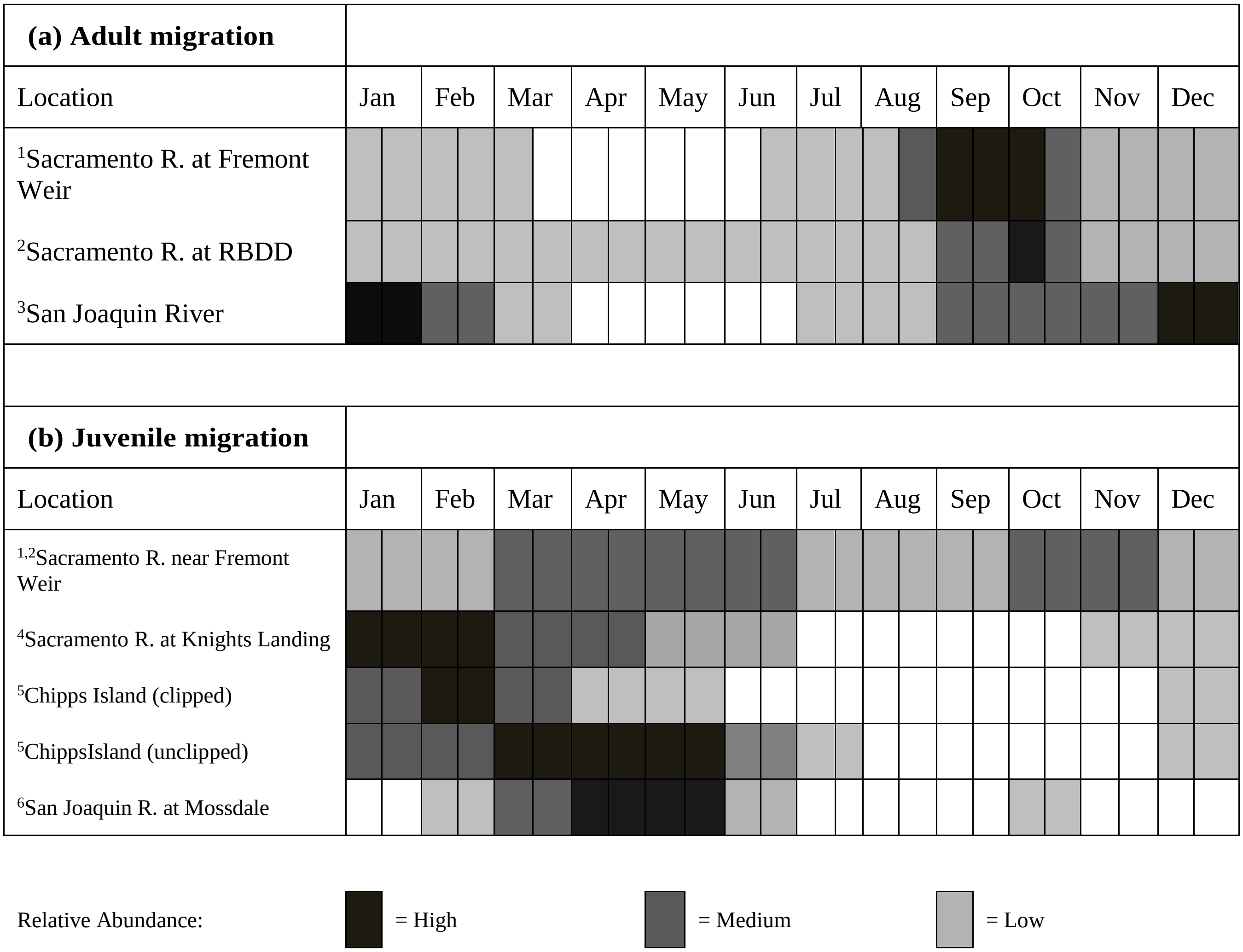
The status of spring-run critical habitat in the action are is discussed in Section 2.4.2.3.

2.4.2.2 Status of California Central Valley steelhead in the action area

CCV steelhead exhibit a similar life history to CV spring-run Chinook and occupy a similar geographical range (see Appendix XX). As described in section 2.3.1.2 above, CCV steelhead also extensively utilize the Sacramento River, Lower American River and Sacramento/San Joaquin Delta. Assessing the temporal occurrence of each life stage of CCV steelhead in the action area is done through analysis of monitoring data in the Sacramento River and select tributaries; monitoring in the Delta; and salvage data from the Tracey and Skinner fish collection facilities in the south Delta (CVP and SWP) (Table 2-4). The only portion of the action area to contain spawning habitat is the Lower American River.

Table 2-3 shows the temporal occurrence of (a) adult and (b) juvenile California Central Valley steelhead at locations in the action area. Darker shades indicate months of greatest relative abundance.

Table 2-3. The temporal occurrence of (a) adult and (b) juvenile California Central Valley steelhead at locations in the action area.



Sources: [1](Hallock 1957); [2](McEwan 2001); [3]CDFG Steelhead Report Card Data 2007; [4]NMFS analysis of 1998-2011 CDFW data; [5]NMFS analysis of 1998-2011 USFWS data; [6]NMFS analysis of 2003-2011 USFWS data.

Spawning adults enter the San Francisco Bay estuary and Delta from August to November (with a peak in September [(Hallock *et al.* 1961)]). Spawning occurs in a number of tributaries to the Sacramento River, to which the Delta and Sacramento River serve as key migratory corridors (National Marine Fisheries Service 2014c). Spawning occurs from December to April, with a peak in January through March, in rivers and streams where cold, well oxygenated water is available (Hallock *et al.* 1961, McEwan and Jackson 1996, Williams 2006). Adults typically spend a few months in freshwater before spawning (Williams 2006), but very little is known about where they hold between entering freshwater and spawning in rivers and streams. Utilization of the Delta by adults is also poorly understood.

Juvenile CCV steelhead rear in cool, clear, fast-flowing streams and are known to prefer riffle habitat over slower-moving pools (National Marine Fisheries Service 2014c, Reclamation 2015). The only portion of the action area containing optimal juvenile rearing habitat for CCV steelhead is the Lower American River, where juveniles belonging to the natal population are known to exhibit rearing behavior prior to outmigration (Reclamation 2015). The Sacramento River and Delta are likely utilized primarily as migratory corridors. Little is known about the rearing behavior of juveniles in the Delta; however, they are thought to exhibit short periods of rearing and foraging in tidal and non-tidal marshes and other shallow areas prior to their final entry into the ocean.

The Lower American River contains a naturally spawning population of CCV steelhead, which spawn downstream of Nimbus Dam. The dam is an impassable barrier to anadromous fish, isolating historical spawning habitat located in the North, Middle and South forks of the Upper American River. The American River population is small, with only a few hundred individuals returning to spawn each year (Reclamation 2015). In recent years, spawning adults have been observed with intact adipose fins indicating that a portion of the in-river population is of wild origin (Hannon 2013). Juvenile O. mykiss have been observed to occupy fast-flowing riffle habitat in the Lower American River, which is consistent with known life history traits of this species.

Nimbus hatchery, located on the Lower American River adjacent to Nimbus Dam, produces the anadromous form of *O. mykiss*; however, steelhead from Nimbus hatchery are not included in the CCV steelhead DPS.

The portion of the lower San Joaquin River within the Delta is used by migrating adult and juvenile CCV steelhead to reach spawning and rearing grounds in the tributaries (FISHBIO 2012, FISHBIO 2013, California Department of Fish and Wildlife 2013).

Although steelhead will experience similar effects of climate change to Chinook salmon, as they are also blocked from the vast majority of their historic spawning and rearing habitat, the effects may be even greater in some cases, as juvenile steelhead may rear in freshwater over the summer prior to emigrating as smolts (Snider and Titus 2000). Several studies have found that steelhead require colder water temperatures for spawning and embryo incubation than salmon (McCullough et al. 2001). McCullough et al. (2001) recommended an optimal incubation temperature at or below 11°C to 13°C (52°F to 55°F), and successful smoltification in steelhead may be impaired by temperatures above 12°C (54°F) (Richter and Kolmes 2005). In some areas, stream temperatures that currently provide marginal habitat for spawning and rearing may become too warm to support wild steelhead populations in the future.

2.4.2.3 Status of Central Valley Spring-run Chinook salmon and California Central Valley steelhead critical habitat in the action area

A significant portion of designated critical habitat for both CV spring-run Chinook and CCV steelhead is contained within the proposed action area. PBFs for both species are concurrently defined in (September 2, 2005, 70 FR 52488) and the following PBFs, in summary, for these species are present in the proposed action area: (1) freshwater spawning sites, (2) freshwater rearing sites, (3) freshwater migration corridors, and (4) estuarine areas.

Critical habitat for CV spring-run Chinook includes portions of the north Delta, as well as the Sacramento River and the Lower American River (from the confluence with the Sacramento River to the Watt Avenue Bridge). With the exception of Clifton Court Forebay, the entirety of the proposed action area is designated critical habitat for CCV steelhead.

Historically, both CV spring-run Chinook and CCV steelhead spawned in many of the headwaters and upstream portions of the Sacramento and San Joaquin River basins. Similar to winter-run Chinook salmon, passage impediments have contributed to substantial reductions in the populations of these species by isolating them from much of their historical spawning habitat. Naturally spawning spring-run Chinook salmon have been extirpated from the San Joaquin River basin entirely, however, an experimental population has been reintroduced to the river under section 10(j) of the ESA and "spring-running" adults have been documented migrating into the San Joaquin tributaries (Franks 2014). Within the action area, spawning habitat for CV spring-run is currently limited to the mainstem of the Sacramento River between Red Bluff and Keswick Dam. CCV steelhead spawn in this reach of the Lower Sacramento River as well as throughout the Lower American River between its confluence with the Sacramento River up to Nimbus Dam. The PBF of freshwater spawning sites for these species has been degraded within the action area due to high water temperatures, redd dewatering, and loss of spawning gravel recruitment in reaches below Keswick Dam (Wright and Schoellhamer 2004, Good *et al.* 2005, National Marine Fisheries Service 2009a, Jarrett 2014). These issues are actively addressed by adaptive flow management in both rivers as well as spawning gravel augmentation projects in both reaches (National Marine Fisheries Service 2009d, 2015a, 2016b).

Freshwater rearing and migration PBFs have been degraded from their historical condition within the action area. In the Sacramento River and San Joaquin, riverbank armoring has significantly reduced the quantity of floodplain rearing habitat for juvenile salmonids and has altered the natural geomorphology of the river (National Marine Fisheries Service 2014). Similar to winter-run Chinook, CV spring-run and CCV steelhead are only able to access large floodplain areas such as the Yolo Bypass under certain hydrologic conditions which do not occur in dryer years. However, the Yolo Bypass Restoration Plan includes notching the Fremont Weir which will provide access to floodplain habitat for juvenile spring-run Chinook salmon and steelhead over a longer period (Department of Water and Resources and Bureau of Reclamation 2016). Levee construction involves the removal of riparian vegetation, resulting in reduced habitat complexity and shading, making juveniles more susceptible to predation. Additionally, loss of riparian vegetation reduces aquatic macroinvertebrate recruitment resulting in decreased food availability for rearing juveniles (Anderson and Sedell 1979, Pusey and Arthington 2003).

The Lower American River has experienced similar losses of rearing habitat; however, projects sponsored by Reclamation are restoring rearing habitat for juvenile CCV steelhead through the creation of side channels and placement of instream woody material (Reclamation 2015).

Within the proposed action area, the estuarine area PBF includes the legal Delta, encompassing significant reaches of the Sacramento and San Joaquin Rivers that are tidally influenced (September 5, 2005, 70 FR 52488). Due to levee construction, shoreline development, and dramatic alterations to the natural hydrology of the system due to water export operations; estuarine habitat in the Delta is significantly degraded from its historical condition (National

Marine Fisheries Service 2014). Though critical habitat for CV spring-run only occurs in the north Delta, it is thought that some entrainment into the interior Delta may occur during Delta Cross Channel (DCC) gate openings. However, the 2014 drought year prompted protections for CV spring-run at the DCC (National Marine Fisheries Service 2016a). Reverse flows in the Central and South Delta resulting from water exports may exacerbate interior Delta entrainment by confounding flow and temperature-related migratory cues in outmigrating juveniles. The presence of these stressors, which cause altered migration timing and routing, degrade critical habitat PBFs related to rearing and migration.These impacts are discussed in greater detail in Section 1.1.1.1.12 *Hydrodynamics in the Delta*, and effects to critical habitat PBFs in the Delta for CV spring-run Chinook salmon are analyzed in Section 2.5.2.2.4 *Estuarine Habitat for Rearing and Migration*.

2.4.3 sDPS North American Green Sturgeon

2.4.3.1 Status of sDPS North American green sturgeon in the action area

The sDPS green sturgeon exhibit a more complex life history with respect to salmonids and less is known about the ecology and behavior of their various life cycle stages in the action area. Some acoustic telemetry (Kelly *et al.* 2007, Heublein *et al.* 2008) and multi-frequency acoustic survey work (Mora *et al.* 2015) has been done to study adult migration patterns and habitat use in the action area (Delta and Sacramento River). Field surveys have also been conducted on the Sacramento River to study spatial and temporal occurrence of early life stages (Poytress *et al.* 2010, 2011, 2012, 2013, Poytress *et al.* 2015b). These studies have documented some spatial patterns in spawning events on the upper reaches of the Sacramento River. Although Seesholtz *et al.* (2014a) observed spawning in the Feather River, no known spawning events have been observed in the Lower American River or in the portion of the lower San Joaquin River that is included in the Delta. Additionally, several lab studies have been conducted using early life stages to investigate ontogenic responses to elevated thermal regimes as well as foraging behavior as a function of substrate type (Allen *et al.* 2006a, Allen *et al.* 2006b, Nguyen and Crocker 2006, Linares-Casenave *et al.* 2013). However, due to sparse monitoring data for juvenile, sub-adult and adult life stages in the Sacramento River and Delta, there are significant data gaps to describe the ecology of this species in the action area. It is understood that spawning occurs in the upper reaches of the Sacramento River and Feather River (Seesholtz *et al.* 2014b, Poytress *et al.* 2015a), so the mainstem Sacramento and Delta serve as rearing habitat and a migratory corridor for this species. Some rearing also may occur in the lowest reaches of the Lower American River where deep pools occur for rearing of older lifestages (downstream of SR-160 bridge) (Thomas *et al.* 2013). Information gaps encountered in efforts to summarize information on sDPS green sturgeon life history are often addressed using known information about the nDPS.

Southern DPS green sturgeon spawn primarily in the Sacramento River in the spring and summer and the farthest upstream spawning event in the Sacramento River was documented near Ink's Creek at river km 426 (Poytress *et al.* 2015a). However, Heublein (2008) detected adults as far upstream as river km 451 near Cow Creek, suggesting that their spawning range may extend farther upstream than previously documented. The upstream extent of their spawning range lies somewhere below ACID, as that dam impedes passage for green sturgeon in the Sacramento River (Heublein *et al.* 2008). It is uncertain, however, if green sturgeon spawning habitat exists closer to ACID, which could allow spawning to shift upstream in response to climate change effects. Successful spawning of green sturgeon in other accessible habitats in the Central Valley (*i.e.*, the Feather River) is limited, in part, by late spring and summer water temperatures. Similar to salmonids in the Central Valley, green sturgeon spawning in the major lower river tributaries to the Sacramento River are likely to be further limited if water temperatures increase. In a bioenergetics study, 15-19°C was the optimal thermal range for age-0 green sturgeon (Mayfield and Cech 2004). If temperatures in spawning habitat exceed that range in the future, it may reduce the fitness of early life stages.

2.4.3.2 Status of sDPS North American green sturgeon critical habitat in the action area

Critical habitat for sDPS green sturgeon is contained in nearly all of the proposed action area with the exception of the Lower American River from the SR-160 bridge upstream to Nimbus Dam. All PBFs for sDPS green sturgeon critical habitat are present in the action area, except PBFs for nearshore coastal marine areas. The PBFs in the action area include, in summary, (1) food resources, (2) substrate type or size, (3) water flow, (4) water quality, (5) migratory corridor, (6) depth, and (7) sediment quality. These PBFs apply to both riverine and estuarine areas except "substrate type or size" which pertains to spawning habitats and only applies to riverine areas. These PBFs are described in detail in the range wide status of sDPS green sturgeon in Appendix XX.

The historical spawning range of sDPS green sturgeon is not well known, though they are thought to have spawned in many of the major tributaries of the Sacramento River basin – many of which are isolated due to passage impediments (Beamesderfer *et al.* 2004). Green sturgeon utilize the Lower Sacramento River for spawning and are known to spawn in its upper reaches between RBDD and Keswick Dam (Poytress *et al.* 2015a). Similarly to the listed salmonid species addressed in this Opinion, PBFs related to spawning and egg incubation have been degraded as discussed in sections 2.4.1.2 and 2.4.2.3. Changes in flow regimes and the installation of Keswick and Shasta Dams have significantly reduced the recruitment of spawning gravel in the upper reaches of the Lower Sacramento River. Flow conditions in the Sacramento River have also been significantly altered from their historical condition. The degree to which these altered flow regimes effects outmigration dynamics of juveniles is unknown; however, some suitable habitat exists and spawning events have been consistently observed annually (Poytress *et al.* 2015a).

PBFs for sDPS green sturgeon in the lower reaches of the Sacramento River and the Delta have also been significantly altered from their historical condition, similar to the impacts described in sections 2.4.1.2 and 2.4.2.3. However, green sturgeon exhibit very different life history characteristics from those of salmonids and therefore utilize habitat within the proposed action area differently as follows. Green sturgeon are thought to exhibit rearing behavior in the lower reaches of the Sacramento River and the Delta as juveniles and subadults prior to migrating to the ocean, though little is known about the behavior of these lifestages in the Delta (Radtke 1966, National Marine Fisheries Service 2015b). Loss of riparian habitat complexity in the Sacramento River and Delta has likely posed less of a threat to green sturgeon because these life stages are benthically oriented. However, it is likely that reverse flows generated by Delta water exports effect the green sturgeon juvenile and subadult life stages to some degree as evidenced by juvenile captures at CVP/SWP salvage facilities during high water years (California Department of Fish and Game 2002).

2.4.4 Other Factors Affecting Listed Fish Species and Critical Habitat in the Action Area

2.4.4.1 Water Quality

Current land use in the Sacramento River basin and Delta has seen a dramatic increase in urbanization, industrial activity, and agriculture in the last century. In a Sacramento River Basin-wide study, areas with relatively high concentrations of agricultural activity as well as areas that had previously experienced mining activity showed increased concentrations of dissolved solids and nitrite plus nitrate (Domagalski *et al.* 2000). Domagalski (2001) also found varying concentrations of mercury and methylmercury throughout the Sacramento River Basin. Concentrations of these contaminants were greatest downstream of previous mining sites (primarily Cache Creek). Both studies showed lower concentrations of contaminants in the American River as compared to other sites sampled in the Sacramento Basin.

Multiple studies have documented high levels of contaminants in the Delta such as Polychlorinated Biphenyls (PCBs), organochlorine pesticides, Polycyclic Aromatic Hydrocarbons (PAHs), selenium, and mercury, among others (Stewart *et al.* 2004, Leatherbarrow *et al.* 2005, Brooks *et al.* 2011), suggesting that fish are exposed to them; however, the inability to characterize concentrations and loading dynamics makes it difficult to quantify transport and total contaminant loading in the system (Johnson *et al.* 2010). Harmful algal blooms also occur in the Delta and, although toxic exposure of estuarine fish has been documented, the extent of their impacts to the aquatic food web is unknown (Lehman *et al.* 2009). The Environmental Protection Agency (EPA) developed an action plan in 2012 to address water quality concerns in the Delta (U.S. Environmental Protection Agency 2012). This plan included the following actions: 1) Strengthen estuarine habitat protection standards, 2) Advance regional water quality monitoring and assessment, 3) Accelerate water quality restoration through Total Maximum Daily Loads, 4) Strengthen selenium water quality criteria, 5) Prevent pesticide pollution, 6) Restore aquatic habitats while managing methylmercury, and 7) Support the Bay Delta Conservation Plan.

2.4.4.2 Predation

Predation of juvenile salmonids and green sturgeon is thought to be a contributing factor to high mortality at this life stage within the action area, though there is still more research needed on this topic in order to draw any substantial conclusions (Hanson 2009, Michel *et al.* 2015). Within the action area there have been significant alterations to aquatic habitat that are conducive to the success of non-native piscivorous fish such as riverbank armoring and reduction of habitat complexity (National Marine Fisheries Service 2014). A study led by the NOAA Southwest Fisheries Science Center has attempted to develop a quantitative tool to measure predation in the Delta using a novel method of observing predation events at a fine spatial scale (Demetras *et al.* 2016). This study identified some fine scale dynamics of predation on salmonids; however, the results were not comprehensive enough to make any sort of system-wide conclusions regarding the magnitude of predation on juveniles in the Delta.

2.4.4.3 Diversion entrainment

The many existing unscreened water diversions on the Sacramento River pose a threat to early life stages of listed species. A study of 12 unscreened, small to moderate sized diversions (< 150 cfs) in the Sacramento River, found that diversion entrainment was low for listed salmonids (majority were identified as fall-run Chinook based on length-at-date criteria; other ESUs made up much smaller percentages), though the study points out that the diversions used were all situated relatively deep in the river channel (Vogel (2013). Juvenile green sturgeon also contributed to a small percentage of entrainment mortality in this study. In a previous mark-recapture study addressing mortality caused by unscreened diversions, Hanson (2001) also observed low mortality in hatchery-produced juvenile Chinook salmon released upstream of four different diversions throughout the Sacramento River (≤ 0.1 % of individuals released).

2.4.4.4 Dredging and other physical disturbance

Dredging operations periodically occur throughout the action area for a variety of purposes including the maintenance of shipping channels; maintenance of diversion intakes; and to remove accumulated sediments from recreational and commercial facilities such as boat docks and marinas. Dredging can have detrimental impacts to listed fish species through physical disturbance, and through the resuspension of sediment. The adverse effects of dredging operations to anadromous fish are discussed in greater detail in Section 2.5.1.1.3.4 *Dredging* and effects to critical habitat are discussed in Section 2.5.2.1.1 *Sedimentation and Turbidity*. ESA consultations are periodically conducted by NMFS for dredging projects of varying scope and scale throughout the action area (National Marine Fisheries Service 2014b, 2016d).

2.4.4.5 Vessel traffic in the action area

Select portions of the action area currently experience heavy commercial and recreational vessel traffic, creating hazards to listed fish species through both physical and acoustic disturbance. These impacts may lead to direct mortality or may induce changes in behavior that impair feeding, rearing, migration, and/or predator avoidance. Further details on the effects of vessel traffic to fish are included in *Section 2.5.1.1.7 Physical Impacts to Fish*. Within the action area, the Stockton Deep Water Ship Channel (DWSC) and Sacramento DWSC experience frequent large commercial vessel traffic. The mainstem Sacramento River; American River; Delta; and remainder of Suisun, San Pablo, and San Francisco Bays receive occasional commercial tugboat traffic as construction barges and other heavy equipment are transported upstream. Finally, recreational vessel traffic occurs throughout the action area. In a report on Delta boating needs through the year 2020, the California Department of Boating and Waterways stated an expected increase in boating activity in the Delta area (California Department of Boating and Waterways 2003).

2.4.4.6 Acoustic impacts in the action area

Construction activities in the action area occur periodically, and some involve pile driving which generates acoustic effects potentially causing acute injury and/or behavioral impacts to fish. In the last few decades, observed acoustic impacts to fish have prompted research into physiological effects caused by excess sound generated in water (Gaspin 1975, Hastings 1995, Hastings and Popper 2005). These effects are described in greater detail in Section 2.5.1.1.1 *Acoustic Stress*. Recent NMFS biological opinions for projects involving take caused by acoustic-related effects in the action area include bridge replacements at Jelly's Ferry (Sacramento River) and Miner Slough (north Delta) (National Marine Fisheries Service 2014a, 2016c).

2.4.4.7 Restoration Actions from NMFS 2009 OCAP BO

Restoration actions mandated as part of the NMFS 2009 OCAP BO (National Marine Fisheries Service 2009a) are occurring on the upper reaches of the Sacramento River between Keswick Dam and Red Bluff Diversion Dam as well as on the Lower American River between Nimbus Dam and the State Route 160 Bridge (National Marine Fisheries Service 2015a, 2016b). At select sites within these areas, the projects involve creation of side channels, addition of spawning gravel, and placement of IWM. NMFS has determined that these actions are likely to adversely affect listed species as projects are implemented; however, these actions will contribute aquatic habitat with high value for the conservation of listed species and will ultimately contribute to the recovery of ESA-listed salmonids in the Central Valley.

2.4.4.8 Summary of Climate Change Impacts

One major factor affecting the rangewide status of the threatened and endangered anadromous fish in the Central Valley and aquatic habitat at large is climate change.

Warmer temperatures associated with climate change reduce snowpack and alter the seasonality and volume of seasonal hydrograph patterns (Cohen et al. 2000). Central California has shown trends toward warmer winters since the 1940s (Dettinger and Cayan 1995). An altered seasonality results in runoff events occurring earlier in the year due to a shift in precipitation falling as rain rather than snow (Roos 1991; Dettinger et al. 2004). Specifically, the Sacramento River basin annual runoff amount for April-July has been decreasing since about 1950 (Roos 1987, 1991). Increased temperatures influence the timing and magnitude patterns of the hydrograph.

The magnitude of snowpack reductions is subject to annual variability in precipitation and air temperature. The large spring snow water equivalent (SWE) percentage changes, late in the snow season, are due to a variety of factors including reduction in winter precipitation and temperature increases that rapidly melt spring snowpack (VanRheenen et al. 2004). Factors modeled by VanRheenen et al. (2004) show that the melt season shifts to earlier in the year, leading to a large percent reduction of spring SWE (up to 100% in shallow snowpack areas). Additionally, an air temperature increase of 2.1°C (3.8°F) is expected to result in a loss of about half of the average April snowpack storage (VanRheenen et al. 2004). The decrease in spring SWE (as a percentage) would be greatest in the region of the Sacramento River watershed, at the north end of the Central Valley, where snowpack is shallower than in the San Joaquin River watersheds to the south.

Projected warming is expected to affect Central Valley Chinook salmon. Because the runs are restricted to low elevations as a result of impassable rim dams, if climate warms by 5°C (9°F), it is questionable whether any Central Valley Chinook salmon populations can persist (Williams 2006). Based on an analysis of an ensemble of climate models and emission scenarios and a reference temperature from 1951- 1980, the most plausible projection for warming over Northern California is 2.5°C (4.5°F) by 2050 and 5°C by 2100, with a modest decrease in precipitation (Dettinger 2005). Chinook salmon in the Central Valley are at the southern limit of their range, and warming will shorten the period in which the low elevation habitats used by naturally-producing fall-run Chinook salmon are thermally acceptable. This would particularly affect fish that emigrate as fingerlings, mainly in May and June, and especially those in the San Joaquin River and its tributaries.

2.4.5 Importance of the Action Area for the Survival and Recovery of Listed Fish Species

The action area defined for this proposed action includes critical habitat designated for all species of ESA-listed fish addressed in this Opinion. It includes spawning habitat that is critical for the natural production of these species; rearing habitat that is essential for growth and survival during early life stages and enhances overall productivity and population health; migratory corridors that facilitate anadromous life history strategies; and estuarine habitat that serves as additional rearing habitat and provides a gateway to marine phases of their lifecycle.

The NMFS Recovery Plan for the Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon ESUs and the California Central Valley Steelhead DPS (National Marine Fisheries Service 2014c) provides region-specific recovery actions that were identified by NMFS in order to facilitate recovery of these species. Implementation of some of these actions has already begun and more are in the planning phase. A Recovery Outline was produced in 2010 for sDPS green sturgeon and includes a list of recovery tasks specific to the CA Central Valley including the action area (National Marine Fisheries Service 2010). A draft Recovery Plan for sDPS green sturgeon is currently being developed and is scheduled for completion in early 2017.

2.4.5.1 Recovery Actions for the Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon ESUs and the California Central Valley Steelhead DPS Specific to the Action Area

All of the impacts to listed salmonid species and degraded salmonid critical habitat elements addressed above were assessed as threats in our recovery plan (National Marine Fisheries Service 2014). There are many recovery actions identified in our recovery plan, some of which are currently underway. Current implementation of the recovery actions relevant to the action area are described here and should improve conditions for these species into the future. Many of the recovery actions identified for salmonids will also improve conditions for green sturgeon.

<u>Reintroduction to historic habitats</u>

- Develop and implement a program to reintroduce winter-run Chinook salmon, spring-run Chinook salmon, and steelhead to historic habitats upstream of Shasta Dam. The program should include feasibility studies, habitat evaluations, fish passage design studies, and a pilot reintroduction phase prior to implementation of the long-term reintroduction program (NMFS 2009b).

<u>Restore juvenile habitats</u>

Floodplain

- Provide access to new floodplain habitat in the South Delta for migrating salmonids from the San Joaquin system.
- Enhance floodplain habitat in lower Putah Creek and along the toe drain (NMFS 2009b).
- Implement the Southport Floodplain Restoration Project.

Tidal Marsh

- Implement the Prospect Island Tidal Habitat Restoration Project.
- Implement the Chipps Island Tidal Marsh Restoration Project.
- Implement the Eastern Decker Island Tidal Marsh Restoration Project.
- Implement the Dutch Slough Tidal Marsh Restoration Project.
- Restore tidal wetlands and associated habitats at Brannan Island State Park, northeast tip of Sherman Island, along Seven-Mile slough, and the southwest tip of Twitchell Island.
- Implement the Meins Landing Tidal Habitat Restoration Project.
- Implement the Hill Slough Tidal Habitat Restoration Project.
- Implement the Tule Red Restoration Project.
- Implement the Rush Ranch Tidal Habitat Restoration Project.

<u>Improve temperature conditions</u>

- Implement physical and structural modifications to the American River Division of the CVP in order to improve water temperature management (See RPA action II.3 in the 2009 Biological Opinion for the long-term operations of the CVP and SWP) (NMFS 2009b).
- Develop an annual water temperature management plan for the lower American River (NMFS 2009b).

<u>Improve flow conditions</u>

- Develop and implement a river flow management plan for the Sacramento River downstream of Shasta and Keswick dams that considers the effects of climate change and balances beneficial uses with the flow and water temperature needs of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead. The flow management plan should consider the importance of instream flows as well as the need for floodplain inundation (Williams et al. 2009).
- Implement the flow management related actions (i.e., RPA actions II.1 and II.4) identified in the reasonable and prudent alternative from the 2009 Biological Opinion for the long-term operations of the CVP and SWP (NMFS 2009b).
- Develop, implement, and enforce new Delta flow objectives that mimic historic natural flow characteristics, including increased freshwater flows (from both the Sacramento and San Joaquin rivers) into and through the Delta and more natural seasonal and inter-annual variability.
- Through additional releases in the San Joaquin River system, augment flows in the southern Delta and curtail exports during critical migration periods (April-May), consistent with a ratio or similar approach.
- Curtail exports when protected fish are observed at the export facilities to reduce mortality from entrainment and salvage (NMFS (2009b).

<u>Reduce juvenile mortality</u>

- Install NMFS-approved, state-of-the-art fish screens at the Tehama Colusa Canal diversion. Implement term and condition 4c from the biological opinion on the Red Bluff Pumping Plant Project, which calls for monitoring, evaluating, and adaptively managing the new fish screens at the Tehama Colusa Canal diversion to ensure the screens are working properly and impacts to listed species are minimized (NMFS 2009b).

- Identify and implement any required projects to assure the M&T Ranch water diversion is adequately screened to protect winter-run Chinook salmon, spring-run Chinook salmon, and steelhead.
- Evaluate and reduce stranding of juvenile Chinook in side channels in the reach from Keswick Dam to Colusa, due to flow reductions from Keswick Reservoir, by increasing or stabilizing releases from the reservoir.
- Modify existing water control structures to maintain flows through isolated ponds in the Yolo Bypass to minimize fish stranding, particularly following the cessation of flood flows over the Fremont Weir (NMFS 2009b).
- Modify Delta Cross Channel gate operations and evaluate methods to control access to Georgiana Slough and other migration routes into the Interior Delta to reduce diversion of listed juvenile fish from the Sacramento River and the San Joaquin River into the southern or central Delta (NMFS 2009b).

<u>Improve spawning habitat availability</u>

- Develop and implement a long-term gravel augmentation plan consistent with CVPIA to increase and maintain spawning habitat for winter-run Chinook salmon, spring-run Chinook salmon, and steelhead downstream of Keswick Dam.
- Implement a long-term gravel management program in the lower American River to provide suitable spawning habitat per CVPIA.

<u>Improve hatchery management</u>

- Develop and implement a secondary fish trapping location for the Livingston Stone NFH winter-run Chinook salmon supplementation program to provide increased opportunity to capture a spatially representative sample and target numbers of broodstock. Develop criteria and a process for phasing out the Livingston Stone winter-run Chinook salmon hatchery program as winter-run recovery criteria are reached. This hatchery program is expected to play a continuing role as a conservation hatchery to help recover winter-run Chinook salmon.

<u>Reduce adult mortality</u>

- In an adaptive management context, implement short- and long-term solutions to minimize the loss of adult Chinook salmon and steelhead in the Yolo bypass, and Colusa and Sutter-Butte basins. Solutions include:

    - exclusionary device downstream of Wallace Weir fail to block migration of adults
    - Re-operating, to the extent feasible, the Knights Landing outfall gates to help prevent listed fish from entering the Colusa Basin (short-term)
    - Providing and/or improving fish passage through the Yolo Bypass and Sutter Bypass allowing for improved adult salmonid re-entry into the Sacramento River (long-term)
    - Implement the Lisbon Weir Fish Passage Enhancement Project (NMFS 2009b).
    - Restore Liberty Island, Cache Slough, and the lower Yolo bypass (NMFS 2009b).

2.4.6 Southern Resident Killer Whales

There are many factors affecting the Southern resident killer whale population throughout the action area. The primary impact from the proposed action to Southern resident killer whale is the reduction of prey base from negative impacts to the California Central Valley Chinook salmon population in the Pacific Ocean. Therefore, we distinguish below factors affecting the prey of Southern residents from other factors affecting Southern residents.

2.4.6.1 Factors Affecting the Prey of Southern Residents in the Action Area

2.4.6.1.1 Climate Change and Environmental Factors

The availability of Chinook salmon to Southern Residents is affected by a number of environmental factors and climate change. Predation in the ocean contributes to natural mortality of salmon. Salmonids are prey for pelagic fishes, birds, and a wide variety of marine mammals (including Southern Residents). Recent studies have provided evidence that growth and survival rates of salmon in the California Current off the Pacific Northwest can be linked to fluctuations in ocean conditions related to Pacific Decadal Oscillation and the El Nino-Southern Oscillation conditions and events (Peterson *et al.* 2006, Wells *et al.* 2008). Evidence exists that suggests early marine survival for juvenile salmon is a critical phase in their survival and development into adults. The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and a local scale, provides an indication of the role they play in salmon survival in the ocean. Moreover, when discussing the potential extinctions of salmon populations, Francis and Mantua (2003) point out that climate patterns would not likely be the sole cause, but could certainly increase the risk of extinction when combined with other factors, especially in ecosystems under stress from humans.

2.4.6.1.2 Salmon Harvest Actions

NMFS has consulted on the effects of numerous salmon fishery harvest actions that may affect Chinook availability in coastal waters for Southern Residents, including 10-year terms of the Pacific Salmon Treaty (term of biological opinion from 2009-2018; (National Marine Fisheries Service 2008a) and the *United States v. Oregon* 2008 Management Agreement (term of biological opinion from 2008-2017; (National Marine Fisheries Service 2008b), and the Pacific Coast Salmon Plan fisheries (National Marine Fisheries Service 2009c). In these past harvest opinions, NMFS has considered the short-term effects to Southern Residents resulting from reductions in Chinook abundance that occur during a specified time period and the long-term effects to whales that could result if harvest affected viability of the salmon stock over time by decreasing the number of fish that escape to spawn. These past analyses suggested that short-term prey reductions were small relative to remaining prey available to the whales. In the long term, harvest actions have met the conservation objectives of harvested stocks, were not likely to appreciably reduce the survival or recovery of listed Chinook salmon, and were therefore not likely to jeopardize the continued existence of listed Chinook salmon. The harvest biological opinions referenced above have all concluded that the harvest actions cause prey reductions, but were not likely to jeopardize the continued existence of ESA-listed Chinook salmon or Southern Residents.

In 2012, NMFS convened an independent science panel to critically evaluate the effects of salmon fisheries on the abundance of Chinook salmon available to Southern Residents. The Panel found good evidence that Chinook salmon are a very important part of the Southern Resident diet and that some Southern Residents have been in poor condition recently, which is associated with higher mortality rates. They further found that the data and correlations developed to date provide some support for a cause and effect relationship between salmon abundance and Southern Resident survival and reproductions. They identified “reasonably strong” evidence that vital rates of Southern Residents are, to some degree, ultimately affected by broad-scale changes in their primary Chinook salmon prey. They suggested that the effect is likely not linear, however, and that predicted improvements in Southern Resident survival may not be realistic or may diminish at Chinook salmon abundance levels beyond the historical average. Overall, the panel concluded that the impact of reduced Chinook salmon harvest on future availability of Chinook salmon to Southern Residents is not clear and cautioned against overreliance on correlative studies (Hilborn *et al.* 2012).

2.4.6.1.3 Water Operations in the Central Valley

NMFS has consulted on the effects of the long-term operations of the Central Valley Project (CVP) and State Water Project (SWP) in California (National Marine Fisheries Service 2009b). In that analysis, NMFS found that the long-term operations of the CVP and SWP, as proposed, were likely to jeopardize the continued existence of several ESA-listed Chinook ESUs. NMFS concluded that the increased risk of extinction of the winter- and spring-run Chinook salmon, along with loss of diversity in fall-run, as a long-term consequence of the proposed action is likely to reduce the likelihood of survival and recovery of the Southern Resident killer whale DPS, although implementation of the RPA actions for reducing adverse impacts to Chinook salmon was determined sufficient to also reduce adverse impacts on Southern Residents and avoid jeopardy.

2.4.6.1.4 Quality of Prey

As introduced above, contaminants enter marine waters from numerous sources throughout the action area, but are typically concentrated near populated areas of high human activity and industrialization. The majority of growth in salmon occurs while feeding in saltwater (Quinn 2005). Therefore, the majority (> 96 percent) of persistent pollutants in adult salmon are accumulated while feeding in the marine environment (Cullon *et al.* 2009, O'Neill and West 2009). The marine distribution of salmon is an important factor affecting pollutant accumulation as is evident across the different salmon populations. For example, Chinook populations feeding in close proximity to land-based sources of contaminants have higher concentrations (O'Neill *et al.* 2006). In addition, ratios of contaminants in blubber biopsies found that the blubber of K and L pod match with similar ratios of prey species in California, which was indicated by the relatively high concentrations of dichlorodiphenyltrichloroethane (DDT). These DDT fingerprints suggest fish from California form a significant component of their diets (Krahn *et al.* 2007, Krahn *et al.* 2009, O'Neill *et al.* 2012), cited in Hilborn *et al.* (2012).

2.4.6.2 Other Factors Affecting Southern Residents in the Action Area

2.4.6.2.1 Vessel Activity and Sound

Commercial, military, recreational and fishing vessels traverse the coastal range of Southern Residents in the action area. Vessels may affect foraging efficiency, communication, and/or energy expenditure by their physical presence and by creating underwater sound and disturbance (Williams *et al.* 2006, Holt 2008, Holt *et al.* 2011). Collisions of killer whales with vessels are rare, but remain a potential source of serious injury and mortality. Large ships that traverse coastal waters of the whales' range move at relatively slow speeds and are likely detected and avoided by Southern Residents.

Sound generated by large vessels (*e.g.*, large ships, tankers, and tugs) is a major source of low frequency human-generated sound (5 to 500 Hz) in the world's oceans (National Research Council 2003). At close range large vessels can be a significant source of background noise at frequencies important to the whales (Holt 2008). Commercial sonar systems designed for fish finding, depth sounding, and sub-bottom profiling are widely used on recreational and commercial vessels and are often characterized by high operating frequencies, low power, narrow beam patterns, and short pulse length (National Research Council 2003). Many of these sound sources fall within the hearing range of many marine mammals, including Southern Residents, and may produce masking effects of other important sound detection or communication abilities.

2.4.6.2.2 Non-Vessel Sound

Anthropogenic (human-generated) sound in the range of Southern Residents is generated by other sources besides vessels, including oil and gas exploration, construction activities, and military operations. Natural sounds in the marine environment include wind, waves, surf noise, precipitation, thunder, and biological noise from other marine species. The intensity and persistence of certain sounds (both natural and anthropogenic) in the vicinity of marine mammals vary by time and location and have the potential to interfere with important biological functions (*e.g.*, hearing, echolocation, communication). In the coastal waters of the action area, military sonar and seismic surveys also have the potential to disturb Southern Residents killer whales.

2.4.6.2.3 Oil Spills

Oil spills have occurred in the coastal range of Southern Residents in the past, and there is potential for spills in the future. The magnitude of risk posed by oil discharges in the action area is difficult to precisely quantify, but improvements in oil spill prevention procedures since the 1980s likely provide some reduced risk of spill. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion, pneumonia, liver disorders, neurological damage (Geraci and St. Aubin 1990), potentially death, and long-term effects on population viability (Matkin *et al.* 2008). In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect Southern Residents by reducing food availability.

2.4.6.3 Scientific Research

Research activities on Southern Residents are typically conducted between May and October in inland waters, and some permits include authorization to conduct research in coastal waters as well. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. Recent permits issued by NMFS include research to characterize the population size, structure, feeding ecology, behavior, movement patterns and habitat use of the Southern Residents, especially during the winter and spring when Southern Residents are using coastal waters extensively.

2.4.6.4 Summary of Southern Residents Environmental Baseline

Southern Residents are exposed to a wide variety of human activities and environmental factors in the action area. All the activities discussed above in section 2.4.6 are likely to have some level of impact on Southern Residents when they are in the action area. No single threat has been directly linked to or identified as the cause of the relative lack of growth of the Southern Resident population over time, although three primary threats that have been identified are: prey availability, environmental contaminants, and vessel effects and sound (Krahn *et al.* 2002). There is limited information on how these factors or additional unknown factors may be affecting Southern Residents when in coastal waters; however the small size of the population increases the level of concern about all of these risks (National Marine Fisheries Service 2008c).

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